PROTEUS: A platform to organise transfer inside French robotic community

Philippe Martinet[*], Bruno Patin[**]

*LASMEA
GRAVIR/ROSACE
Campus des cézeaux
63177 Aubière, France

***Dassault Aviation*
78, Quai Marcel Dassault
Cedex 300
92552 SAINT CLOUD Cedex, France

Abstract

Last decades have seen the emergence of autonomy as a paradigm for the development of robots. Due to the many existing studies and many different actors working in this scope, many control architectures were developed either in laboratories or in industries, either in France or elsewhere. This proliferation obliterates capability to exchange easily ideas, software, hardware, etc. The end of the 90', through the RTP 17 efforts [1], and the first two CAR conferences among many other occasions emphasised the need for some way to ease the transfer between the different actors of the field, academics as well as industrials. Through the "GDR[1] Robotique" and its associated partners' club emerged the idea to promote a study inside the CONTINT[2] call of the ANR[3] that would tackle with this problematic at least inside the French Robotic community. This project is called PROTEUS (A platform to organise transfer inside French robotic community) and is presented in some detail in the following text.

Keywords

Control; Architecture; Robot; Platform; ANR

1 INTRODUCTION

The PROTEUS presentation begins by its rationnale then proceeds

2 RATIONALE

The PROTEUS project (***P***lateforme pour la ***R***obotique ***O***rganisant les ***T***ransferts ***E***ntre ***U***tilisateurs et ***S***cientifiques) goal is to create a toolset that would facilitate transfer of knowledge from the academic world toward the industrial one and problems from the industrial world toward the academic one.

This toolset will be constituted following two main considerations:

[1] Groupement De Recherche
[2] CONtenus et INTeractions
[3] Agence Nationale de la Recherche

- Field oriented considerations through the production towards the academic world of sets of scenarios translating industrial problems. These scenarios would be implemented in runable environment. This axis takes into account the capability for the actors of the field to use real robots operated by end-users in order to directly assess their achievements (cognition, control algorithms, etc.) onto real robots;
- Software oriented considerations that take into account tools to facilitate knowledge transfer, executable environments creation, and methodologies to make these enabling resources easily exploitable by a large community of adopters. The work to be done on this axis will be to provide a minimal formal language to support the description of scenarios and model integration facilities (model means here an external component, either stand alone or library one that provides access point and capability to be externally sequenced).

In order to make this work available over the end of the project itself, another consideration will be to define the legal aspects that concern these tools and how it will be accessible by users and developers. One of the possible solutions will be for the "GDR Robotique" website to take into account these availabilities concerns.

As the robotic field is too large to be considered completely, the consortium will restrict itself to its mastered fields. For the time being it means mainly aerial and terrestrial robotic as well as humanoid robotic. Other fields will be considered after this first step.

Another key orientation of the project is the pragmatic approach adopted. Each time the partners will consider a tool will not be used, its development will be stopped, following the principle that less tools largely used is better than more tools never used. In order to help the consortium consolidate its choices, the "GDR Robotique" scientific committee and its associated partners' club will be consulted every six months.

3 BACKGROUND, STATE OF THE ART, ISSUES AND HYPOTHESIS

3.1 Context

The PROTEUS project follows the work already achieved inside the industrial partners' club associated to the French "Groupement De Recherche Robotique" research group and of its consolidation with the "Groupement de Recherche Robotique" itself. This work has been completed through discussions with the academic partners and the GDR moderation to a common point of view leading us to recognise the limits of nowadays collaborations methodologies (if any are used).

Thus, from these two points of view emerge a need for tools that can be called platform. Such a need was already described some years ago. During year 2003, the RTP17 [1], emitted a call for national platform in order to answer this specific problem. Due to reorganisation, this call was frozen and the subject not addressed until future time.

This platform is clearly itself a multi-faceted research domain and the state of the art would be too long if we had to list the numerous researches that relate to it. We therefore choose to focus the presentation of the scientific context on the points where we believe we will bring a significant contribution: which robotic domains are concerned, simulations tools used, modelling and analysis tools that help the setup of simulations tools.

3.2 Robotic domains

Robotic includes various application domains either considering the used robots or considering the services offered. A non exhaustive survey allows distinguishing:

- Unmanned aerial vehicles [3];
- Unmanned ground vehicles [4];
- Humanoid robots [5], [6], [7];
- Personal and Domestics robots.

Due to the expertise of the partners present in the project, the consortium will restrain itself to the UAV, UGV and domestic robots. It is the belief of the consortium that the tools defined and developed will be of usable in other robotic domains.

3.3 Robotic simulation

Mobile robotics is a complex research area. Technologies include electronics, mechanics, computer hardware and software. It is often difficult to master perfectly every technology. Realistic simulations and fast prototyping of mobile robots help reducing the amount of time and hardware spent. Moreover, such software tools allow researchers and students to focus on the most interesting parts of their robotics projects.

Real experiments with physical robots are both expensive and time consuming. Simulators can save a lot of time. Many tools [8], [9] exist nowadays. USarSim [10], **Breve** [11] or **netLogo** [12] are good examples of such tools.

Sometimes it can become necessary to couple several different simulators because of the complexity of what to simulate or property's problems. Several approaches and tools exist, for example the High Level Architecture [13] or DEVS [14].

This profusion leads to the difficulty to exchange / compare robots' specification, sensors' models, decision's algorithms, etc. Here follows a very short list of some simulation tools or frameworks:

- **Webots** [16]: tries to provide a rapid prototyping environment;
- **Gazebo** [17]: a 3D multiple robot simulator;
- **URBI** [18]: a framework provided by one of the partner;
- **Microsoft Robotic Platform** [19]: solution proposed by Microsoft;
- Etc.

Already initiatives exist in order to decrease these problems such as **Open Simulation Architecture** [20]: a French initiative that tries to create open simulation architecture. There are also efforts to promote a theory of the simulation, for example, the VerSim [21] group of "I3 Groupement de Recherche".

Another problem for robotic simulation is the capability to represent reality. There are many different sensors such as sonar, radar, lidar, vision based and so on. To represent them correctly can require resources out of the scope of even a company. How to tackle with this multiplicity of models is a key point. Some previous work was done defining the "minimal simulation". Nevertheless realistic models are promoted by some frameworks such as:

- Robotic Reusable Robotic Framework [22];
- LAAS architecture (GenoM [39]).

Thus, the context of the robotic simulation tools and frameworks is a very diverse one that does not ask for other equivalent tools but requires to be consolidated.

3.4 Tools for modelling and analysing robotic systems

Ontologies: Ontologies can be used to model robots and their environment and validate it. An ontology [23] defines knowledge structure for a given domain. Ontology for robotics [24] can be helpful for normalization of mechanical and electronic component models, as well as control architectures.

Domain specific languages: DSL[4] is a programming language designed for, and intended to be useful for, a specific kind of task. Several initiatives there again try to promote this approach such as Athéna [25], MARTE [26] OpenEmbeDD [27], SysML [28], etc.

3.5 Robotic standards

There is already some basic work (like vocabularies definition) done by organizations like ISO (International Standard of Organization) or **ASTM** [33][34].

Some other actions exist at the European level such as **RoSta** [35] (specific of the robotic field), **OMG** Robotics **DTF** [37] (Domain Task Force)) or **EUROn** group of interest [38].

4 PROTEUS

4.1 Organisation

In order to create a platform facilitating the transfer as described in 2, a methodology was defined by a group of partners mixing academics and companies, robotic experts and software engineering ones. In order to assume the leadership of such a group, it was decided that a joint lead by academic and company would be done. In order to verify at each step that there would be choices relevant of the community's needs, a committee composed of members of the GDR Robotique, of the partners club and other institutions / organisations such as DGA[5] will monitor progress each six months. Lastly, workshops will be organised in order to present the whole community the different results in order to assure feedback.

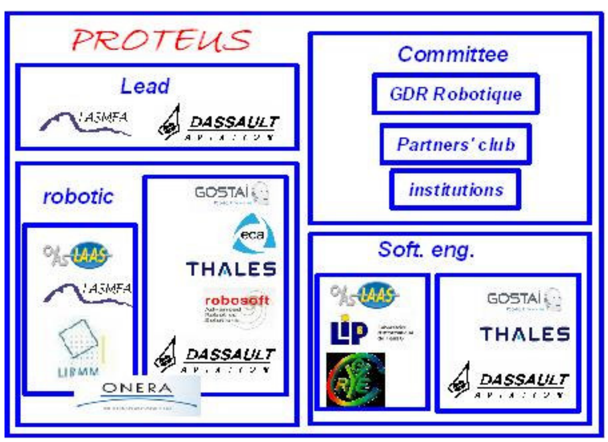

Figure 1: Organisation of the partners

4.2 Definition of the work

In order to implement such a platform and verify its efficiency and capability to really answer to the problems we have, we defined a methodology that introduces real challenges that should allow:

[4] Domain-specific programming language
[5] Délégation Générale de l'Armement

- Internally to PROTEUS to validate the set of tools and standards;
- Externally to validate their usability by the community.

Thus, PROTEUS is divided in two main parts, one that is in charge of the development of the platform itself and the second one dedicated to their validation to the field. The challenges will be real ones with associated metrics. PROTEUS will accompany these challenges with specific metrics allowing it to measure the actual use done by those participating of the different set of tools.

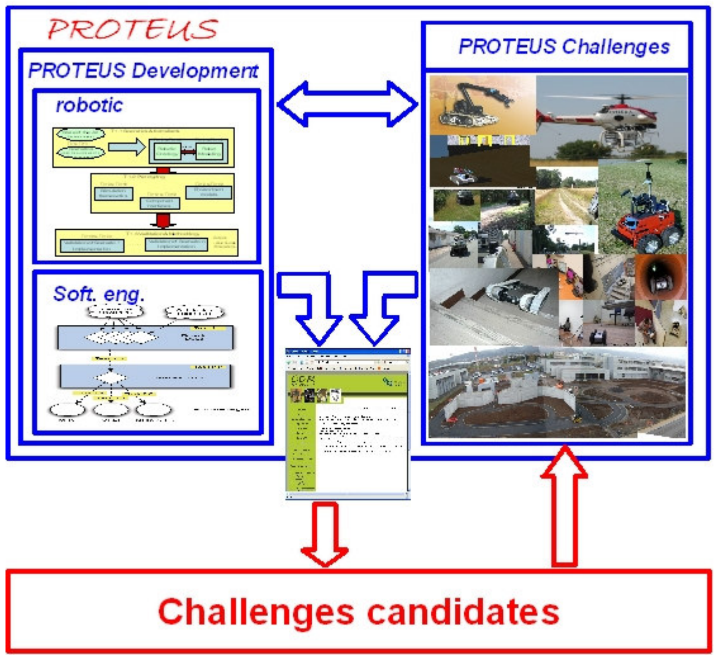

Figure 2: definition of PROTEUS workflow

Thus during the course of the project, the partners will provide GDR Robotique the definition of the challenges and the associated tools and standards developed. The GDR will then announce the opening of the challenges and the capability for those willing to subscribe. They will then download from the GDR Robotique website the elements related to the challenge or challenges to which they will concur plus those forms that they will have to give back in order for PROTEUS to have data on the toolset use and apply the metrics defined before.

For those working with the toolset and able to provide validated solutions to the challenges, events will be organised before the end of PROTEUS letting them test their work on real robots such as R-Trooper evolving in real environment such as the one existing in LASMEA - Clermont-Ferrand [40].

PROTEUS will end its work synthesising the reality of the toolset uses, results coming out the different challenges, opinions of challenges' candidates of the toolset and the possible improvements coming out this synthesis.

The sections that follow detail the development work needed by PROTEUS.

The work to be done during the course of this project concerning management is of utmost importance. It is this reason why it is the first of the work packages. In order for this project to succeed, coordination will have to be done with respect to:

- The different work packages of the project. In fact, there will be outputs of tasks necessary to realise the work of other tasks and even if we will try to split work and minimise these exchanges in order to reduce risks, there will remain such very important links (see below);

- The different worlds involved in the project. This project will mix teams issued of the academic and industry worlds. The management will have to manage the link between them in order to avoid misunderstandings and maximise use of the results in these two worlds;

Deliveries and meetings management will be the other tasks of this work packages.

4.2.1 Robotic

The following schematic describes in some more detail what has to be done during "robotic" development.

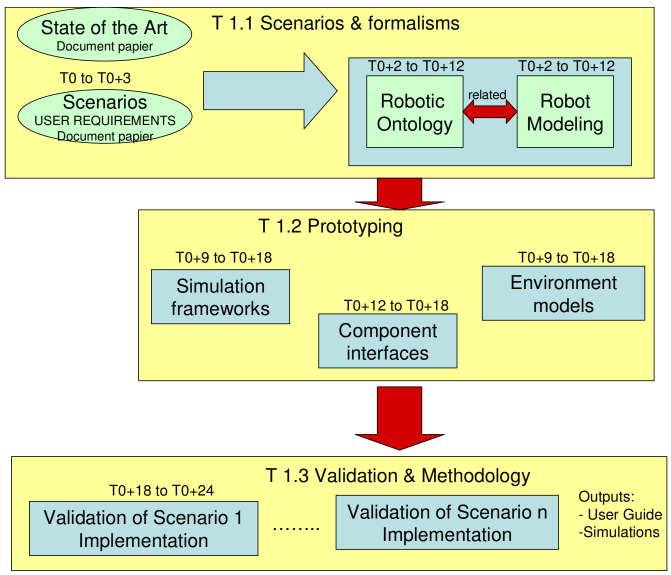

Figure 3: description of the WP1 work

Scenario & formalism

State of the art

This activity will deliver a state of the art, at the scientific level, dealing with the various components that should be developed in order to address the proposed scenario. It will analyse what is feasible in terms of scenarios, types of environment, robots, components to be integrated, existing object description and ontology initiatives.

Specification of the scenarios, robots that are concerned and associated problems

This task consists in defining operational and functional scenarios in the field of humanoid and air-land robotics. The scenarios will be consistent with the challenges.

The scenarios description will act as user requirements for the ontology and model description, and will condition the validation task (i.e., the validation will check the users requirements issued from the scenarios).

The scenarios will describe for each field (indicative non exhaustive list): the mission description, the robot associated objects description, the environment description.

The description will emphasize on scenarios which remains consistent with the further level of description by simulation (for example, it seems more likely to address mission level scenarios related to operational missions or autonomy, more than embedded behaviours related to the vehicle or humanoid motion).

Robotic ontology and modelling

This activity aims to formalize the above specified scenario in a non ambiguous way. This will be done in 2 parts: the description of data and structure using the ontology paradigm and the description of architecture, activities and data flows using an Athéna-like tooling [25].

Prototyping

This task addresses the general topic of the expected environment required by the platform. PROTEUS will be used to evaluate performances of "robotic items" ranging from low level algorithm to high level behaviours: Such evaluations will be held using simulated or real challenges which will be partly (real ones) or fully (simulated ones) implemented on the platform.

To implement such a challenge, one would have to:

- Describe the problem in a scenario and define the expected results;
- Provide the platform with *models*, which means description of robot, environment and robot-environment interactions, which comply with the formal description established in previous task.
- Implement the models on the platform and proceed to the evaluation.

It is important to take into account that the relevance of evaluation will tightly depends on the quality of input models.

Validation and methodology

The aim of this step is to generate the scenarios that will embody the problems described using the outputs of the above tasks and the tools developed through the following work package.

For each of the described challenges, we will use the available tools and apply the methodology. Each partner in charge of a challenge will describe the different scenarios provided in the challenge using DSLs. Functional validation of the challenge will be ensured by using PROTEUS tools and methodology.

4.2.2 Languages and tools

The goal of this work package is to provide languages and tools to support the definition and the simulation of scenarios. A scenario is the description of robots which accomplish a mission in a given environment. A DSL (Domain Specific Language) combines a vocabulary (primitive types and functions) with the ability to capture abstractions specific to the domain. Compared with general-purpose modelling languages such as the UML, DSLs only offer a limited set of constructs. This increases modelling productivity and facilitates a precise definition of concerns within a particular domain. The description of a robotic simulation: missions, environments, robots control will be done with the help of several dedicated modelling languages and then weave together with the help of ontologies descriptions to produce an abstract description of the robotic simulation. Finally, we expect to produce an executable simulation for different targets.The figure below illustrates the work to be done.

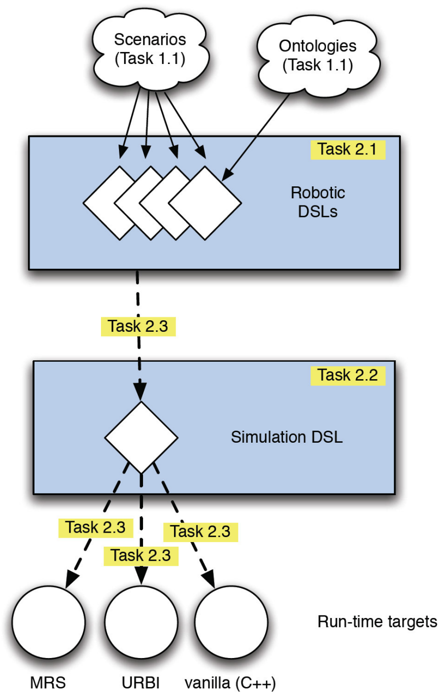

Figure 4: description of the "languages and tools" work

Domain Specific Modelling Languages for Robotic

The aim of this task is to provide domain specific languages (and related tools like editors, consistency checkers, etc ...) suitable to specify missions, environments and robots behaviours provided by the Task 1.1. Why do we need a DSML for robotic? Robots are rather complex physical and software systems that integrate several specific concerns. A robotic DSL should be able to describe among the different aspects: robots missions (objectives and goals), robotic mechanisms, robot software control, users requirements, metrics, etc ... Usually a robotic system is only decomposed in a modular fashion in functional parts, but unfortunately there are concerns of robotic systems that relate to the systems as a whole hence crosscutting their modular structure. So in order to do that, we need to propose several DSLs for each concern.

From the user perspective, it becomes necessary to have a set of graphical notations associated with these DSLs. Instead to define a new notation, it will be more interesting to reuse existing standard industry notation like UML (Unified Modelling Language) [OMG]. So, one of the challenges of this task is to study the possibility to reuse UML and its diagrams (***Structural diagrams*** and ***Behavioural diagrams***) to specify some DSL construction. This needs a clear study on UML diagrams to identify what kind of diagrams is adapted to the robotic DSL? And how these diagrams can be integrated?

Integrate DSLs with an ontology level

Modelling complex systems like robotic system usually requires several different DSL, which raises the need to consistently integrate the corresponding models. Semantic relationship between constructs from different languages should be explicitly defined. We need an approach that facilitates this integration of domain-specific languages on a semantic level by mapping language constructs to concepts in domain ontology. Thus, we will work on the suitable integration of ontologies descriptions provided by the "Robotic" development part to DSLs.

The main outcome of this task will be the design of a domain specific language suitable for the simulation of robotic systems. We plan to rely on the already existing modelling language Athéna, used. We envision that a simulation program will be obtained by unfolding ontologies in an appropriate way with the generation tools.

Transformation models and code generation

The goal of this task is to define and implement the transformations to execute the simulations using the languages defined in above. Three execution targets will be aimed at: URBI, Microsoft Robotic Studio and a vanilla execution with minimal functionality.

An agile iterative approach will be used to define the transformations their controlling strategies using a high-level language (such as Stratego [42] or TOM [43]).

4.3 Dissemination and Exploitation

The most difficult objective of PROTEUS is to make such a platform adopted and used throughout the French robotic community, ensuring continuity after the end of the project itself. It means that PROTEUS will take care of disseminating information thanks to conferences but also through existing national and international workgroups but favouring the GDR Robotique. It will take care of the property rights to be applied on what will be done using the experience of its different partners, for example what has been done for the JRL [41] will help us understanding what showstoppers exist and what actions will be necessary to allow protection and, often in contradiction, dissemination. At the same time it will be necessary to provide the way after the project allowing improvements, adding functionalities and the like to the existing platform.

This work will be done under the tutelage of the GDR Robotique and its associated partners' club that is representative of the French community.

5 CONCLUSION

The PROTEUS project's goal is an ambitious one that will not succeed if not supported by the French robotic community. During its infancy, communications will be done to different conferences and workshop in order to have criticisms even before its start (if any) from this community. The CAR conferences are one of these occasions more so because it emphasises the control architecture of robots as an important field of robotics where standardisation and common tools should exist. Thus PROTEUS will adapt its content to the criticisms as delivered by the audience in order to improve what will be its end results in order for them to be used as largely as possible throughout the French community. Success will mean the capability for this community to enlarge these problems towards other robotic fields such as ROV or Surgery robots and towards other actors such as the European or world ones.

References

[1] http://www.lirmm.fr/w3rob/RTP17/.
[2] http://www.lirmm.fr/CAR06/ et http://www-src.lip6.fr/homepages/car2007/
[3] Links on http://en.wikipedia.org/wiki/Unmanned_aerial_vehicle webpage; many European projects existed or exists, for example, http://www.comets-uavs.org/
[4] Links to be found on http://en.wikipedia.org/wiki/UGV webpage
[5] http://www2.laas.fr/JRL-France/
[6] http://www.aldebaran-robotics.com/
[7] www.robocup.org/
[8] For example https://softs.laas.fr/openrobots/wiki/
[9] http://www.prolexia.fr/english/frame_anglais.htm
[10] http://usarsim.sourceforge.net/
[11] www.spiderland.org/
[12] http://ccl.northwestern.edu/netlogo/
[13] https://www.dmso.mil/public/transition/hla/
[14] http://www.sce.carleton.ca/faculty/wainer/standard/
[15] http://vlab.unm.edu/
[16] http://www.cyberbotics.com/products/webots/
[17] http://playerstage.sourceforge.net/index.php?src=gazebo
[18] http://www.urbiforge.com/
[19] msdn.microsoft.com/robotics/
[20] http://osa.inria.fr/wiki/
[21] http://www.lsis.org/versim/
[22] http://claraty.jpl.nasa.gov
[23] T. R. Gruber. Toward principles for the design of ontologies used for knowledge sharing. Presented at the Padua workshop on Formal Ontology, International Journal of Human-Computer Studies, Vol. 43, Issues 4-5, Nov 1995, pp. 907-928
[24] Deplanques, P. (1996). Vers le Test de l'Autonomie des Robots : une Ontologie de la Robotique. PhD thesis, Université de Montpelier II
[25] http://dassault.ddo.net/athena/
[26] http://omgmarte.org
[27] http://openembedd.org/
[28] www.sysml.org/
[29] http://www.kermeta.org/
[30] http://www-src.lip6.fr/homepages/car2007/papers/blanc-delatour.pdf
[31] http://www.haskell.org/frob/
[32] Peterson J., Hager G.D., and Hudak P. , **A Language for Declarative Robotic Programming**,IEEE International Conference on Robotics and Automation, Volume 2, Issue , 1999 Page(s):1144 - 1151, vol.2.
[33] http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=15532
[34] http://www.astm.org/cgi-bin/SoftCart.exe/DATABASE.CART/REDLINE_PAGES/E2521.htm?E+mystore
[35] Robot Standard, http://www.robot-standards.org/
[36] http://wiki.robot-standards.org/index.php/Ontologies
[37] http://robotics.omg.org/
[38] http://www.euron.org/activities/sigs/expMeth.html
[39] http://www.laas.fr/~sara/RIA/RIA-genom.html.fr
[40] http://tims.univ-bpclermont.fr/pavin.php
[41] http://www2.laas.fr/JRL-France/
[42] http://www.program-transformation.org/Stratego
[43] http://tom.loria.fr/